UCID- 19227-82

U. S. ENERGY FLOW - 1982

C. K. Briggs
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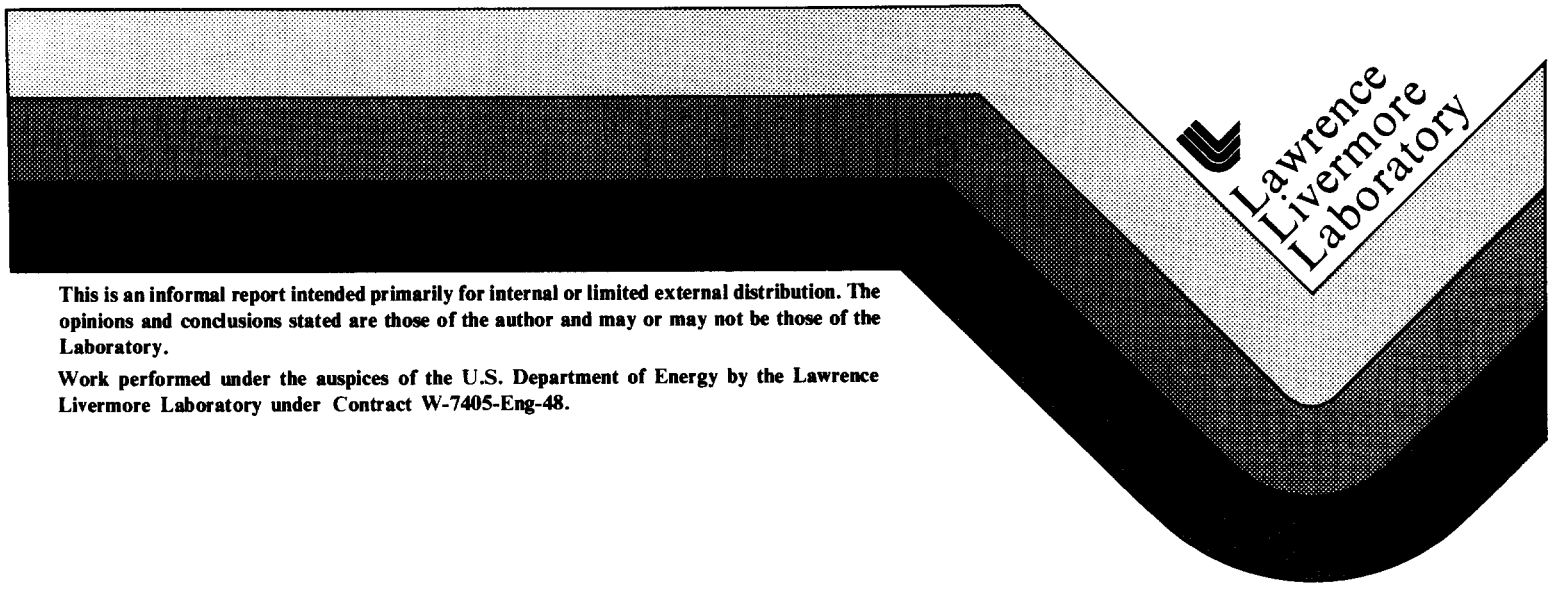
July 29, 1983



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Abstract

Flow diagrams describing the U.S. energy situation have been prepared since 1972 by the Lawrence Livermore National Laboratory. A diagram for 1982 has been prepared which is consistent with past conventions. The 70 quads (70×10^{15} Btu) of energy consumed is down from 73 quads in 1981 and 75 quads in 1980. The trend reflects a prolonged recession and price driven conservation reflecting the increase in international crude oil prices.

Although oil continues to dominate the energy picture by comprising 42% of all energy input, its use continued to decline in 1982. Principal petroleum product reflecting the decline in use is residual oil. Motor gasoline use declined only slightly despite improved fleet mileages. Crude oil imports absorbed the decline in oil use. Mexico took over as the U.S.'s prime supplier with Saudi Arabia as number two. Coal conversions principally for electric power generation stabilized during 1982 probably because associated capital costs to retro-fit oil and gas facilities proved onerous. As a consequence, coal use in the U.S. in 1982 was close to that of 1981. Natural gas use fell largely due to curtailed activity within the industrial sector. Nonetheless the ratio between energy consumption and GNP as measured in constant dollars fell again.

Electrical power generation fell several percent, the first decrease since World War II. Nuclear power provided 12.6% of electrical power with 60 GW_e available capacity. Coal provided 53%.

INTRODUCTION

United States Energy Flow Charts tracing primary resource supply and end-use have been prepared by members o the Energy and Resource Planning Group at the Lawrence Livermore National Laboratory since 1972.[1] They are convenient graphical devices to show relative size of energy sources and end-uses since all fuels are compared on a common Btu basis. The amount of detail on a flow chart can vary substantially, and there is some point where complexity begins to interfere with the main objectives of the presentation. The charts shown here have been drawn so as to remain clear and be consistent with assumptions and style used previously.

ENERGY FLOW CHARTS

Figures 1 and 2 are energy flow charts for calendar years 1982 and 1981[2] respectively.

Data for the flow chart were provided by tables in the Department of Energy Monthly Energy Review, DOE/EIA-0035[3] and the 1982 Annual Energy Review[4].

The Residential and Commercial Sector consists of housing units, non-manufacturing business establishments, health and educational institutions, and government office buildings. The Industrial Sector is made up of construction, manufacturing, agriculture, and mining establishments. The Transportation Sector combines private and public passenger and freight transportation and government transportation including military operations. Utility electricity generation includes power sold by both privately and publicly owned establishments.

U.S. ENERGY FLOW – 1982
(NET PRIMARY RESOURCE CONSUMPTION 70 QUADS)

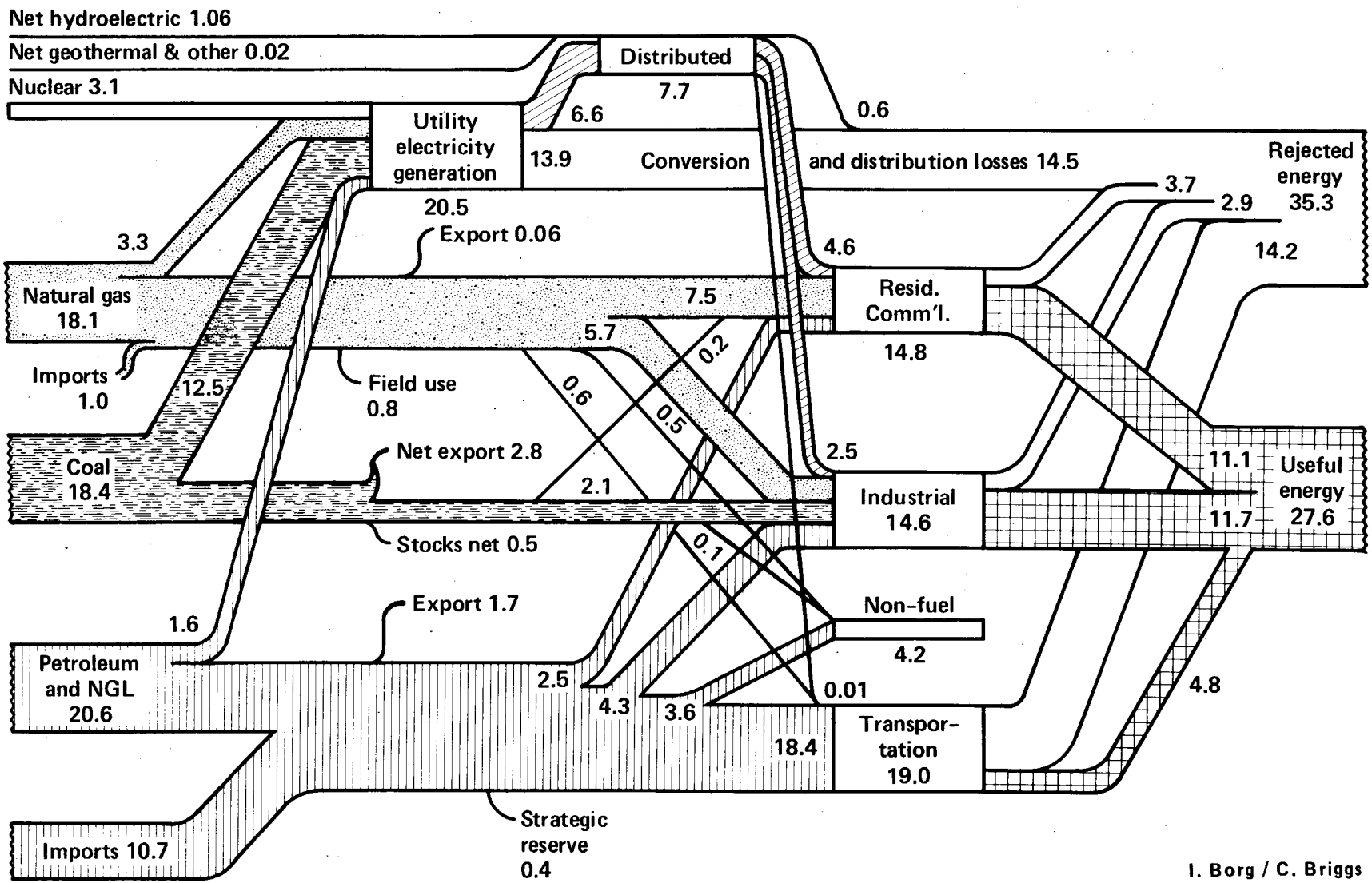
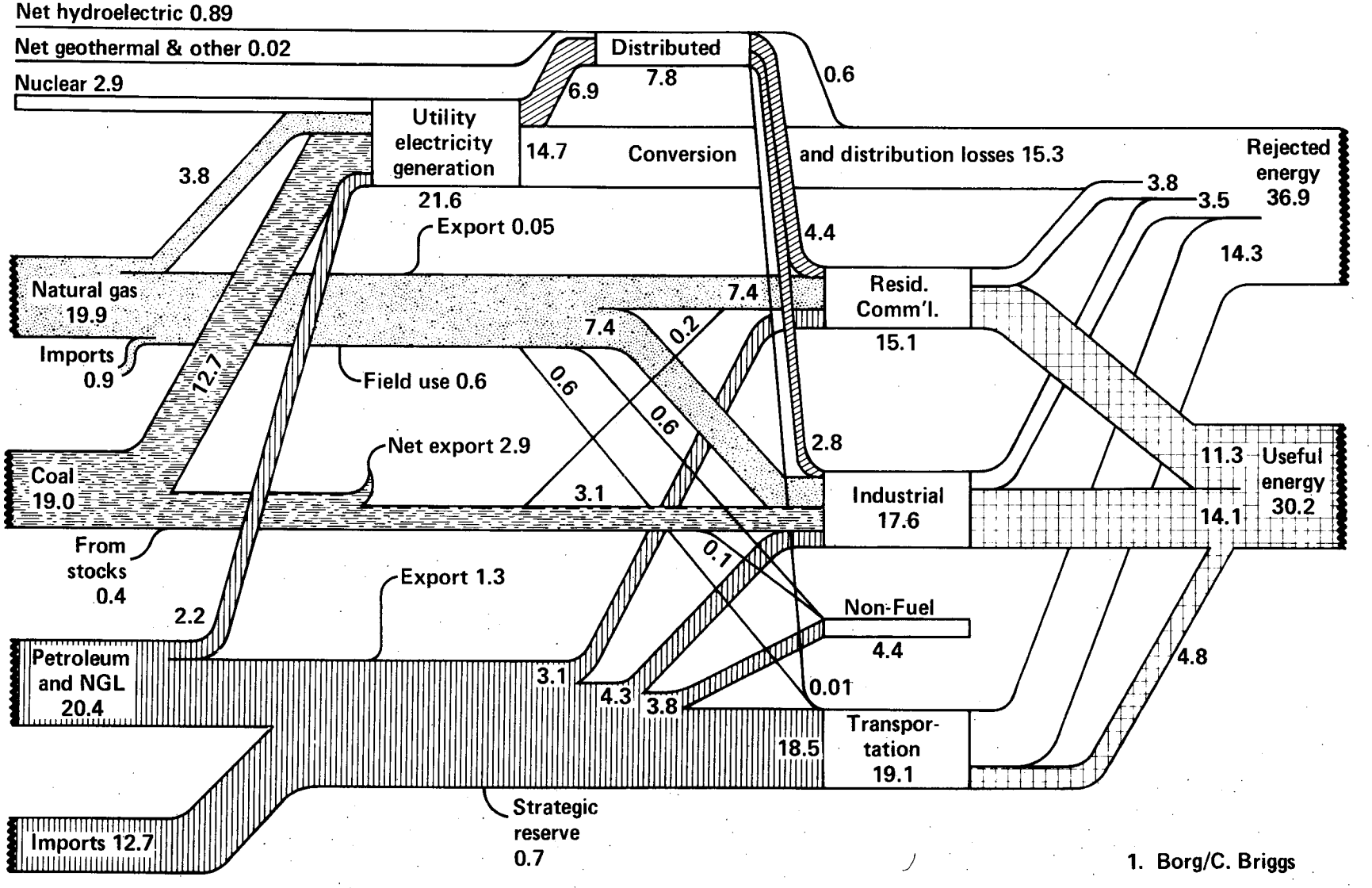


Figure 1

U.S. ENERGY FLOW – 1981
(NET PRIMARY RESOURCE CONSUMPTION 73 QUADS)



1. Borg/C. Briggs

Figure 2

The appendix lists conversion factors used in converting fuel quantities to Btu.

The division between "useful" and "rejected" energy is arbitrary and depends on assumed efficiencies of conversion processes. In the residential and commercial end-use sectors, a 75 percent efficiency was assumed which is a weighted average between space heating at approximately 60 percent and electrical lighting and other electrical uses at about 90 percent. Eighty percent efficiency was assumed in the industrial end-use sector and 25 percent in transportation. The latter percent corresponds to the approximate efficiency of the internal combustion engine.

COMPARISON WITH 1981 AND PAST YEARS

Figures 1 and 2 provide graphic comparison energy use for 1982 and 1981. Starting in 1981 we added a non-fuel category of end-use. Until 1980 it was included in the industrial usage. It consists of fuels that are not burned to produce heat, e.g., asphalt, road oil, petrochemical feedstrocks such as ethane, liquid gases, lubricants, petroleum coke, waxes, carbon black and crude tar. Coking coal traditionally is not included. The breakdown of energy usage by DOE is based on preliminary data which probably accounts for minor inconsistencies apparent in the flow charts. Table 1 lists the consumption of energy resources in the United States for the past five years and gives percentage differences between 1981 and 1982.

The data in Table 1 reflect substantial revisions in historical data reported by DOE (see Monthly Energy Review March 1983 p. 36 for explanation). There are some differences between data on total energy consumption and data

Table 1. Comparison of annual energy use in U.S.

	Quads					
	1977	1978	1979	1980	1981	1982
Natural gas	19.57	19.49	20.08	19.92	19.69	18.09
Imports	1.01	0.97	1.25	0.99	0.90	0.97
Crude oil and NGL						
Domestic crude & NGL	19.78	20.68	20.39	20.51	20.45	20.59
Foreign imports (incl. products & SPR)	18.64	17.70	17.90	14.63	12.69	10.67
Exports	0.51	0.77	1.00	1.15	1.26	1.73
SPR storage reserve*	0.04	0.34	0.14	0.10	0.71	0.37
Net use (minus exports and SPR)	37.87	37.27	37.15	33.89	31.17	29.16
Coal (incl. exports)	15.83	15.04	17.65	18.64	18.44	18.45
Electricity						
Hydroelectric (utility) (net only)	0.75	0.96	0.96	0.94	0.89	1.06
Geothermal & other (net only)	0.01	0.01	0.02	0.02	0.02	0.02
Nuclear	2.70	3.02	2.72	2.74	2.97	3.08
Gas	3.29	3.30	3.61	3.81	3.76	3.34
Coal	10.25	10.24	11.26	12.12	12.58	12.53
Oil	3.90	3.99	3.28	2.63	2.20	1.57
Total fuel	20.90	21.52	21.85	22.26	22.42	21.60
Total transmitted energy	7.25	7.53	7.67	7.80	7.83	7.65
Residential and commercial	15.86	16.05	15.73	15.10	14.57	14.75
Industrial	24.63	24.58	25.64	23.89	22.60	20.02
Transportation	19.75	20.54	20.42	19.65	19.45	19.04
Total consumption** (DOE/EIA)	76	78	79	76	74	71

* Strategic petroleum reserve storage began in October, 1977.

**Note that this total is not the sum of entries above.

Source: Monthly Energy Review DOE/EIA-0035 (83/03) Revised data as of March 1983. Some figures differ from those on earlier flow charts.

presented in Table 1 and Figure 1 due to our conventions that exclude coal stocks and oil put into the strategic petroleum reserve from consumption. Further, hydropower is given by DOE in gross quads (10^{15} Btu) whereas it is listed as a net input in Figures 1 and 2. Thus the sum of inputs and end uses of energy shown in Figures 1 and 2 must also be increased by about 2.5 Quads in order to reflect hydropower losses of various sorts and to agree with DOE totals of 71Q and 74Q.

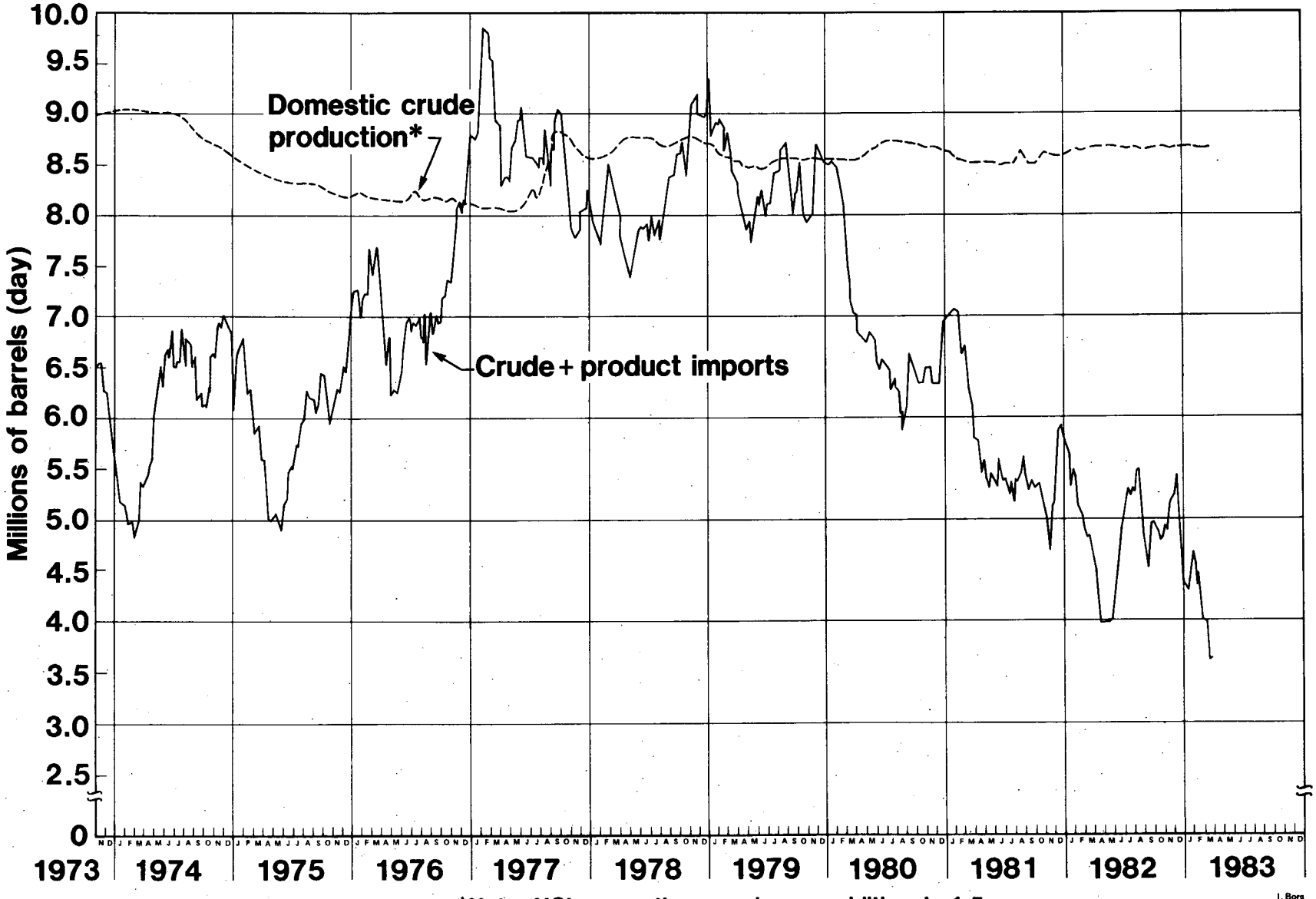
For the fifth consecutive year net oil use declined in the U.S. Substantial declines between 6.4 and 8.6% occurred in the 1980-82 period. Almost all of the drop was in foreign imports (Figure 3). Domestic oil production increased slightly over the previous few years totals. Combined drop in oil and gas usage accounts for the drop in total energy consumption in 1981 and 1982. As in 1981 the principal oil product whose use fell was residual oil (Table 2) and to a lesser extent distillate oil. Both fuels are being affected by fuel switching on the part of the utilities to coal and to natural gas. Even with depressed prices for crude oil, petroleum products remained much higher than alternate hydrocarbon fuels when compared on a Btu basis.

Overall motor gasoline fuel use stayed at 1980-1981 levels. Apparently increased efficiencies associated with smaller cars and mandated mileage have been compensated for by more cars on the road.

The strategic Petroleum Reserve rose to 294 million barrels from 230 million at the end of 1981. A dramatic shift in the source of U.S. oil imports occurred in 1982. By year end OPEC sources accounted for only 41% of total imported volumes.(5) In 1981 OPEC averaged 66.3% of U.S. supply with Saudi Arabia accounting for 25% of total imports. By September 1982, Mexico

PETROLEUM IMPORTS AND DOMESTIC PRODUCTION

Moving four week average



*Note: NGL currently comprise an additional ~1.5 million barrels/day domestic oil production

Figure 3

Table 2. Petroleum products.*

	10^3 barrel/day (average)						
	1976	1977	1978	1979	1980	1981	1982
Motor gasoline	6,978	7,177	7,412	7,034	6,579	6,588	6,537
Jet fuel	987	1,039	1,057	1,076	1,069	1,011	1,010
Distillate fuel oil	3,133	3,352	3,432	3,311	2,866	2,829	2,672
Residual fuel oil	2,801	3,071	3,023	2,826	2,508	2,088	1,695

*Refined petroleum product supplied: sum of production, imports, net withdrawals from primary stocks minus exports.

Source: Monthly Energy Review, DOE/EIA-0035 (83/03);
1982 Annual Energy Review, DOE/EIA-0384 (82) April 1983.

was the U.S.'s largest single supplier and Saudi Arabia number two. The respective averages for the year were 18.7% (Mexico) and 14.6% (Saudi Arabia)[5].

The only other fuel showing decreased use was natural gas. High prices - real or imagined - are blamed together with the continuing recession The average well head price was $2.42 per thousand cubic feet, 22 percent above 1981 levels. Natural gas prices were far from parity with petroleum prices on a Btu basis. The bulk of the decline in use was in the industrial sector.

The volume of coal produced in 1982 was at 1981 levels, but consumption declined slightly (Table 3). Demand for coking coal in domestic and foreign markets fell reflecting the world wide recession and drop in steel production.

Total transmitted electrical energy has remained nearly constant since 1980. A slight drop of a few percent is the first since World War II. Fuels burned for power generation continued to be dominated by coal (61%). With falling oil prices fuel switching to coal has slowed somewhat. The continuing recession has similarly affected plans to retrofit oil and gas burning electrical generating equipment to burn coal. Nuclear power provided 12.6% of domestic electrical generation - a slight increase over 1981 operations. There were 79 licensed nuclear reactors with a capacity of 64 GW_e. Available capacity, which takes deratings, start-up capacities and reactors in a long term shut-down status into account, is about 60GW_e*. The 1982 situation reflects the licensing of 5 additional reactors with 5 GW_e available capacity during the year. At year end there were two reactor units on order.

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*Excludes reactors at Humboldt, Ca, Dresden-1, and both reactors at Three-Mile Island.

Table 3. Coal Use 1981-1982

		1981 Final	1982 Prelim.
DOMESTIC CONSUMPTION			
Electric Utilities		596	593
Coking Coal		61	41
General Industry and Retail		72	70
Total Domestic Markets		729	704
EXPORTS TO			
Canada:	Steam	12	13
	Metallurgical	6	5
	Total	18	18
Overseas:	Steam	33	27
	Metallurgical	59	60
	Total	92	87
Total Exports		110	105
TOTAL CONSUMPTION		839	809
CONSUMER STOCKPILES			
Net Change		-20	+9
TOTAL DEMAND		819	818
PRODUCTION			
East		548	556
West		270	273
Total U. S.		818	829
Imports		1	1
TOTAL SUPPLY		819	830

Source: Department of Energy

1982 - Another depression year

By all accounts 1982 was not a good year for U.S. industry and the economy in general.[6] The GNP fell several percent and was at 1979 levels in constant dollars. The drop in energy consumption from about 73 to 70 quads occurred in almost all end-use sectors but most notably in the industrial sector. Not surprisingly industrial production as monitored by the Federal Reserve Board fell throughout the year (Figure 4). The energy to GNP ratio continued to fall from 1973 highs but at a slower rate than in the past. The oil consumption to GNP ratio (quads per trillion 1972 dollars) fell even faster than the energy/GNP ratio indicating that conservation and other factors than those associated with a recession are responsible for the drop in overall energy use.

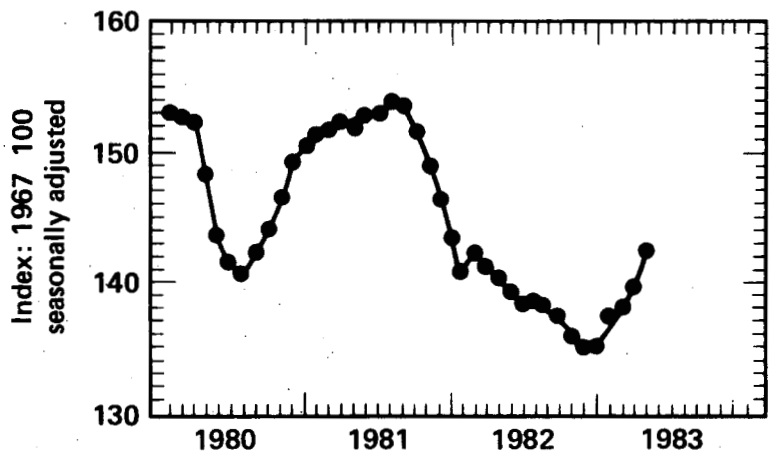

Figure 4 Industrial Production

REFERENCES

1. A. L. Austin, Energy Distribution Patterns in the U.S.A. for 1970 and 1985, Lawrence Livermore National Laboratory Report UCID 16022, 1972.

2. C. K. Briggs and I. Y. Borg, U.S. Energy Flow - 1981, Lawrence Livermore National Laboratory Report UCID 19227-81, October 1, 1982.

3. Monthly Energy Review, DOE/EIA-0035 (83/03).

4. 1982 Annual Energy Review, DOE/EIA-0384 (82), April, 1983.

5. Petroleum Intelligence Weekly, February 28, 1983, p. 7.

6. L. Naturman, Editorial, Energy, VIII No. 1, p. 1, Winter 1983.

APPENDIX: CONVERSION FACTORS

The energy content of fuels varies. Some approximate, rounded conversion factors, useful for estimation, are given below.

Fuel	Energy Content (Btu)
Short ton of coal	20,400,000
Barrel (42 gallons) of crude oil	5,800,000
Cubic foot of natural gas	1,000
Kilowatt hour of electricity	3,400
Fossil fuel to produce one kilowatt hour of electricity	10,400

More detailed conversion factors are given in the Department of Energy's Monthly Energy Review.

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